

Citation Analysis of Computer Science Literature

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Abstract

The purpose of this paper is to analyze and evaluate the citation behavior and use pattern of computer scientists/researchers. The study reveals many important indicators pertaining to computer science literature relating to citation behavior of computer science research. Firstly, almost all the bibliographic document types were referred by the authors, however, the primary research literature i.e. journals and conference proceedings were dominated most. Like most of the scientific disciplines, the citations were scattered among core journals and core authors and have been contributing mainly in development of the subject, being the high quality sources. The citing literature 'half-life' indicates the dominance of current citations/literature.

Keywords: Computer Science, Citation Analysis, Scientometrics

1. Introduction

A large number of studies on bibliometrics and citation analyses in particular have been conducted and are being conducted in almost every discipline and also in multidiscipline area of studies in science and technology¹⁻⁸. Few bibliometric studies have also been found in computer science⁹⁻¹³. But no study has been reported on citation analysis of ACM journals in particular.

Therefore, the intend of the present study is to find out the citation characteristics and trends in the fields of Computer Science research, from references appended to each of the articles published in the Source "Journal of the ACM", for 10 years in between 1999 and 2008.

2. Objectives

The main objective of this study is to find out the different characteristics of citations in the Source Journal, in terms of:

- 1) The year wise distribution of citations, the rate of citations per article, and the use pattern of different type of documents cited.
- 2) The core and essential journals and the classic publications in the field of Computer Science.
- 3) The authorship pattern of citations, and highly ranked/core authors.
- 4) The Citing 'Half-life' of the literature in the field.

3. Methodology

The Association for Computing Machinery (ACM), being the oldest organization in the world on the subject, the first groups was formed in 1947-48 by the computer industry. The Journal of the ACM, started in 1954 and published 6 times a year by ACM, is the oldest and famous journal in the fields of Computer Science. The Journal of ACM has been considered for the period of 1999-2008 as a source journal for citation analysis in view of the objectives of the study.



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4. Data analysis and interpretation

4.1 Citation availability in Journal of the ACM:

In the present study, the citations were collected from "Journal of the ACM", first published in 1954, for 10 years during 1999-2008. A total number of 336 pa-

pers published in "Journal of the ACM" during 1999-2008 (Table-I). There were 15 articles found with no citation or reference. Further, 321 articles, excluding 15 articles without citations, comprise of 10799 citations.

Table I: Availability of Citations in the Journal of the ACM during 1999-2008

No. of Article with Citations	No. of Articles without Citations	Total no. of Articles	Total no. of citations
321	15	336	10799

4.2 Year-wise Distribution of Citations

Table -II summaries the year-wise distribution of citing articles with corresponding citations and rate of citation per article in a particular year. The highest number of articles was 53 published in the year 2003, whereas 28 articles were the lowest in year 2008. The highest number of citations was found in

2001, consisting of 1360 citations, whereas the lowest citations found in 2008 with 975 citations. However, the highest average of citations per article was 37.25 in the year 2005 and the lowest average of citation per article was 18.66 in the year 2003. The overall average of the citations per article for the period 1999 to 2008 was 32.14.

Table II: Year Wise Distribution of Citations

S.no	Year	Total Number of Articles	Total Number of Citations	Average citation per article
1	1999	30	1000	33.33
2	2000	35	1219	34.83
3	2001	38	1360	35.79
4	2002	30	1032	34.40
5	2003	53	989	18.66
6	2004	32	997	31.16
7	2005	29	1088	37.52
8	2006	29	1018	35.10
9	2007	32	1121	35.03
10	2008	28	975	34.82
Total	336	10799	32.14	

4.3 Bibliographical Distribution of Citations

The various forms of documents have been cited by the authors in the citing articles, like- books, com-

posite books, journals, theses, websites, and other documents. Like other emerging scientific disciplines, in the Computer Science also the most cited sources

were primary sources i.e. journals and conference proceedings and further, both of them together have shared 77% of the total citations. Of 10799 citations, the journals have been cited the most, contributing 4565 citations, accounting for 42.27%, which was followed by conference proceedings, contributing 3789, accounting for 35.09%. Books holds third positions, contributing 1474, accounting for 13.64%, which was followed by composite books (244 citations, accounting for 2.25%), websites (152 citations, accounting

for 1.41%), handbooks (137 citations accounting for 1.27%), and dissertations (109 citations, accounting for 1.01%) and other forms (86 citations accounting for 0.79%). Table III depicts the comparative position in regard to the pattern of use of different bibliographical forms by the authors during the study period. As such no specific trend has been found as most of the cited forms have similar distribution in all years.

Table III- Year-wise Comparative Study of Bibliographical Distribution of Citations in Citing articles

Document Type	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total
Journal	477	561	602	429	429	406	323	447	494	398	4566(42.25%)
Proceeding	310	393	467	360	337	380	408	359	385	390	3789(35.09)
Book	115	163	158	141	146	101	320	128	119	83	1474(13.64%)
Report	21	24	32	17	17	30	9	22	29	22	223(2.06%)
Composite Book	36	34	38	18	24	19	5	23	28	19	244(2.25%)
Website	6	2	13	34	14	12	4	19	17	31	152(1.41%)
Handbook	6	14	19	19	3	23	5	4	33	11	137(1.27%)
Dissertation	12	15	16	7	8	14	9	10	7	11	109(1.01%)
Others	17	9	12	6	8	11	5	5	6	6	85 (0.79%)
Grand	1000	1215	1357	1031	986	996	1088	1017	1118	971	10779

4.4 Chronological Distribution of Citations and Aging of Literature

In the present study, there were 24 citations, where year of publication was not ascertained, thus, the total number of 10775 citations was analyzed to compare the chronological distribution of cited documents. Table - IV shows the chronological distribution of citations which covers the time period from 1781 to 2008. This period has been grouped into 11 groups, each group represents one decade, except the first group which covered the period from 1781 to 1908. It was observed that the decade 1989-1998 had the highest number of citations, 4741 citations,

accounting for 43.90%, which was followed by 1999-2008, 3242 citations, accounting for 30.02%, and the next by 1979-1988, 1732 citations, and accounting for 16.04%. All three consecutive decades, 1970-1988; 1989-1998 and 1999-2008 had contributed almost 90% of the citations.

Table – IV: Chronological Distribution of Citation Chronological distribution of citation

S.No.	Year	Document Citation	Percentage of Citations
1	1781-1908	16	0.15
2	1909-1918	5	0.05
3	1919-1928	7	0.06
4	1929-1938	28	0.26
5	1939-1948	25	0.23
6	1949-1958	99	0.92
7	1959-1968	240	2.22
8	1968-1978	640	5.93
9	1979-1988	1732	16.04
10	1989-1998	4741	43.90
11	1999-2008	3242	30.02
	Blank	24	0.22
		10799	100.00

4.5 Chronological Distribution of Journal Citations

There were total 4558 citations from journals where the year was mentioned and eight citations found without year. Table -V presents the chronological distribution of journals citations, which covered the time period from 1813 to 2008. Like the overall chronological distribution of citation, the similar trend has been observed and the recent three decades i.e.1979-88, 1989-98 and 1999-2008 have contributed 3952 citations which is more than 83% ((86.56)of the total citations (shown in table – V).

Table V: Chronological Distribution of Journal Citations Chronological distribution of journal citations

S.No.	Year	Journal Citation	Percentage of Citations
1	1813-1908	8	0.18
2	1909-1918	3	0.07
3	1919-1928	6	0.13
4	1929-1938	17	0.37
5	1939-1948	17	0.37
6	1949-1958	48	1.05
7	1959-1968	156	3.42
8	1968-1978	351	7.69
9	1979-1988	961	21.05
10	1989-1998	1909	41.81
11	1999-2008	1082	23.70
	Without year	8	0.18
		4566	100.00

4.6 Half-life of Literature in Computer Science

Table - VI shows the overall half-life of literature in the computer science, half-life of journals and half-life of proceedings. The overall half-life of computer science literature was 14 years, whereas 16 years in Journals literature and 12 years in proceeding literature. The overall half-life of computer science literature indicates that the libraries on computer science can consider in their acquisition policy to acquire 14 years back literature as being most active life of literature. For researchers, they should consult the journals and conference proceedings at least for last 16 years and 12 years respectively from the current year while doing their research on computer science and allied subjects as being most active current literature, covering 50% of the active literature of total literature during this period.

Table VI: Half-life of Literature in Computer Science

Year	Total Citation			Journals Citation			Proceeding Citation		
	No of Citation	%	Cumulative %	No of Citation	%	Cumulative %	No of Citation	%	Cumulative %
2008	21	0.19	0.19	7	0.15	0.15	10	0.26	0.26
2007	75	0.69	0.89	25	0.55	0.7	35	0.92	1.19
2006	142	1.31	2.2	52	1.14	1.84	69	1.82	3.01
2005	242	2.24	4.44	70	1.53	3.37	126	3.33	6.34
2004	291	2.69	7.14	89	1.95	5.32	142	3.75	10.08
2003	362	3.35	10.49	114	2.5	7.82	184	4.86	14.94
2002	431	3.99	14.48	133	2.91	10.73	235	6.2	21.15
2001	491	4.55	19.03	139	3.04	13.78	250	6.6	27.75
2000	523	4.84	23.87	211	4.62	18.4	212	5.6	33.34
1999	664	6.15	30.02	242	5.3	23.7	291	7.68	41.02
1998	682	6.32	36.34	236	5.17	28.87	299	7.89	48.92
1997	693	6.42	42.75	256	5.61	34.47	281	7.42	56.34
1996	589	5.45	48.21	228	4.99	39.47	234	6.18	62.51
1995	588	5.44	53.65	245	5.37	44.83	207	5.46	67.98
1994	477	4.42	58.07	219	4.8	49.63	170	4.49	72.47
1993	421	3.9	61.97	170	3.72	53.35	151	3.99	76.45
Without year	24	0.22	100	8	0.18	100	0	0	0
Total	10799	100		4566	100	200	3788	100	200

3.7 Authorship Pattern

The contributors of literature are the vital constituent in any field of knowledge. So they can help in developing some important indicators pertaining to the citation analysis of any field. Therefore, the cited authors were analysed to determine the authorship pattern (single v/s multiple), the significant or core authors available in the subject. Of 10799 citations, there were only 10643 citations which had authors

name, whereas 24 citations were found either without authorship or having corporate authorship. Table - VII presents a year-wise distribution of authorship. Only 3926 citations (36.88%) have been authored by single author, whereas 6719 citations (63.12%) were authored by more than one authors (i.e. multiple authors). It is evident that in computer science being one of the emerging discipline, most of the studies have been cited which were collaborative in nature as compare to individual article.

Table -VII: - Year-wise Distribution of Authorship Pattern

Year	Single		Two		Three		Four		Five		More than five		Total		Multiple-authorship	
	No of Authors	%	No of Authors	%	No of Authors	%	No of Authors	%	No of Authors	%	No of Authors	%	No of Authors	%	No of Authors	%
1999	395	3.71	345	3.24	153	1.44	64	0.6	22	0.21	13	0.12	992	9.32	597	5.61
2000	512	4.81	433	4.07	191	1.79	58	0.54	11	0.1	9	0.08	1214	11.4	702	6.59
2001	505	4.74	518	4.87	203	1.91	88	0.83	23	0.22	16	0.15	1353	12.7	848	7.97
2002	420	3.95	350	3.29	180	1.69	48	0.45	18	0.17	8	0.08	1024	9.62	604	5.67
2003	382	3.59	323	3.03	169	1.59	65	0.61	24	0.23	20	0.19	983	9.23	601	5.65
2004	336	3.16	342	3.21	210	1.97	65	0.61	23	0.22	13	0.12	989	9.29	653	6.13
2005	405	3.8	376	3.53	119	1.12	70	0.66	20	0.19	17	0.16	1007	9.46	602	5.66
2006	281	2.64	392	3.68	201	1.89	79	0.74	33	0.31	22	0.21	1008	9.47	727	6.83
2007	368	3.46	394	3.7	236	2.22	74	0.7	30	0.28	14	0.13	1116	10.5	748	7.03
2008	322	3.02	337	3.17	189	1.78	70	0.66	22	0.21	19	0.18	959	9.01	637	5.98
	3926	36.88	3810	35.8	1851	17.39	681	6.4	226	2.12	151	1.42	10645	100	6719	63.12

3.8 Core authors in Computer Science Literature

Table - VIII indicates the ranking the core authors, according their usefulness, the name of the authors who have been cited at least 20 times were considered. The first five positions in the rank were occupied by O, Goldreich, M. Y. Vardi, A, Wigderson, E, Tarjan Robert, M, Thorup. O, Goldreich holds first position, contributing 105 citations, which accounts for 0.47% of the total citations. M. Y. Vardi. held second position, contributing 81, accounting for

0.36%, A, Wigderson held third position, contributing 71, accounting for 0.32%, E Tarjan, Robert held fourth position contributing 69, accounting for 0.31%, M, Thorup, contributing 62, accounting for 0.28%, of the total citations.

Table -VIII: Rank list of core authors

S.No.	Rank	Name of Author	No. of Citation	Percentage of Citations	Cumulative Citation	Cumulative Percentage
1	1	Goldreich O.	105	0.47	105	0.47
2	2	Vardi M. Y.	81	0.36	186	0.83
3	3	Wigderson A.	71	0.32	257	1.15
4	4	Tarjan Robert E	69	0.31	326	1.46
5	5	Thorup M.	62	0.28	388	1.74
6	6	Sudan M.	61	0.27	449	2.01
7	7	Goldwasser S	60	0.27	509	2.28
8	8	Gottlob G.	56	0.25	565	2.53
9	9	Ullman J. D.	55	0.25	620	2.78
10	10	Johnson D. S.	54	0.24	674	3.02
11	11	Nisan N	52	0.23	726	3.25
12	11	Yannakakis M.	52	0.23	778	3.48
13	12	Motwani R.	51	0.23	829	3.71
14	12	Raghavan P.	51	0.23	880	3.94
15	13	Vazirani V. V.	50	0.23	930	4.17
16	14	Alon N	48	0.22	978	4.39
17	15	Lynch N.A.	47	0.21	1025	4.6
18	16	Awerbuch B.	46	0.21	1071	4.81
19	16	Micali S.	46	0.21	1117	5.02
20	16	Naor M.	46	0.21	1163	5.23
21	16	Vitter Jeffrey S.	46	0.21	1209	5.44
22	17	Sharir M.	43	0.19	1252	5.63
23	17	Tardos É.	43	0.19	1295	5.82
24	18	Garey M. R.	42	0.19	1337	6.01
25	19	Dechter R.	41	0.18	1378	6.19
26	20	Attiya H.	40	0.18	1418	6.37
27	20	LEISERSON C.E.	40	0.18	1458	6.57
		total	1458	6.57		
		others	20746	93.44	22204	100.16
		Grand Total	22204	100.16		

3.9 Individual Authorship vs Collaborative Authorship:

A study of top core authors whose individual papers were cited maximum. Table -IX depicts a rank list of core authors' individual papers cited 10 and more times, along with their comparison in other positions of authorship in the papers. The core authors' individual papers have been cited only 41.74% of the total papers where as 58.26% of the papers of core authors cited were collaborative papers. The

analysis of primary author position, where either they hold first author position or individual (single) author, showed that the core authors' contribution as a primary authors' paper were cited the maximum, accounting for 63.23% of the total papers, whereas only 36.77% of the papers were written by them either as a second author or more. Highly cited papers of core authors were of collaborative nature, but contributed by them as a primary author.

Table - IX: Rank List of Core Authors according to Solo Authorship and Comparison between Primary and Secondary Authorships

S.No	Rank	Name of Author	Solo Author	Main Author	Secondary author	3 author	4 author	5 author	More than 6 author	Secondary Author Total	Total	solo Author %	%Main author	% Secondary Author
1	1	Thorup M	30	33	9	14	5	1		29	62	48.39	53.23	46.77
2	2	Knuth D.E	25	30	5					5	35	71.43	85.71	14.29
3	3	Goldreich O	22	79	22	4				26	105	20.95	75.24	24.76
4	4	Lamport L	20	26	4	2				6	32	62.5	81.25	18.75
5	5	Milner R	19	25	4					4	29	65.52	86.21	13.79
6	5	Valiant L.G	19	21	3	1				4	25	76	84	16
7	6	Immerman N	17	18	5	1				6	24	70.83	75	25
8	6	Papadimitriou C.H	17	22	12	1				13	35	48.57	62.86	37.14
9	6	Vardi M.Y.	17	23	43	9	5	1		58	81	20.99	28.4	71.6
10	7	Fagin R	16	29	4	1		1	2	8	37	43.24	78.38	21.62
11	7	Reynolds J. C	16	18						0	18	88.89	100	0
12	8	Chazelle B	15	27	2					2	29	51.72	93.1	6.9
13	8	Ullman J. D	15	18	11	21	5			37	55	27.27	32.73	67.27
14	9	Ajtai M	14	29						0	29	48.28	100	0
15	10	Cook Stephen A	13	17	1					1	18	72.22	94.44	5.56
16	10	Dachter R	13	28	12	1				13	41	31.71	68.29	31.71
17	10	Hastad J.	13	22	2	3				5	27	48.15	81.48	18.52
18	10	Nisan N	13	31	14	7				21	52	25	59.62	40.38
19	10	Tarjan Robert E	13	16	31	16	6			53	69	18.84	23.19	76.81
20	10	Thomas Wolfgang	13	13		1				1	14	92.86	92.86	7.14
21	11	Korf R E	12	19	3	1	1			5	24	50	79.17	20.83
22	11	Schrijver A	12	12	1	12				13	25	48	48	52
23	12	Boelaender H L	11	14	2					2	16	68.75	87.5	12.5
24	12	Indyk P.	11	17	1	9	1			11	28	39.29	60.71	39.29
25	12	Sargolzi D.	11	16	9	1				10	26	42.31	61.54	38.46
26	13	Fredrickson G N	10	11		2				2	13	76.92	84.62	15.38
27	13	Karp R M	10	24	11	2	1			14	38	26.32	63.16	36.84
28	13	Lynch N A	10	14	25	6	2			33	47	21.28	29.79	70.21
29	13	Yao A C.	10	10	2	1				3	13	76.92	76.92	23.08
			437	662	238	116	26	3	2	385	1047	41.74	63.23	36.77
		Others	3189								2879			
		Total												
		single cited author/10	1047											
		Others	2879											
			3926											

3.10 Core and Significant Journals in Computer Science

In every subject, there are some journals, which are very close to the subject and the area of research work. These are frequently referred to by the researchers. These highly cited journals are called as "Core Journals". Core journal ranking studies are usually carried out to help in selection of journals and in assessing the significant journals in a particular subject field. Thus, the identification of core journals has a great relevance for a library. The core journals always publish a high concentration of relevant articles on a particular subject and rest of the articles on the subject are scattered among a large number of journals.

Table - X shows the data pertaining to the 35 core journals along with the number of citations. It was observed that the first 35 journals had received approximately 60% of total citations, while 40% of cita-

tions were scattered over 4531 journals. The Journal of the ACM' (JACM) got the first position in the rank, contributing 440 citations, accounting for 9.64% of the total citation received by the journals. Among other top 10 ranked journals in the descending order are: SIAM Journal of Computing, contributing 372 citations, accounting for 8.15%, Journal of Computer and System Sciences, contributing 294, accounting for 6.44%, Theoretical Computer Science, contributing 238, accounting 2.54%, Artificial Intelligence, contributing 109, accounting 2.39%, Algorithmica, contributing 108, accounting 2.37%, Journal of Algorithms, contributing 100, accounting 2.19%, Communications of the ACM, contributing 79, accounting 1.73%, ACM Transactions on Programming Languages and Systems (TOPLAS), contributing 78, accounting 1.71%, These top journals can be subscribed at least by the libraries related to computer science.

Table X: Rank list of Core Journals

Rank List of Journals						
S.No.	Rank	Key Title	Citation	Percentage	Cumulative Citations	Cumulative Percentage
1	1	Journal of the ACM (JACM)	440	9.64	440	9.64
2	2	SIAM Journal on Computing	372	8.15	812	17.78
3	3	Journal of Computer and System Sciences	294	6.44	1106	24.22
4	4	Theoretical Computer Science	238	5.21	1344	29.43
5	5	Information and Computation	116	2.54	1460	31.98
6	6	Artificial Intelligence	109	2.39	1569	34.36
7	7	Algorithmica	108	2.37	1677	36.73
8	8	Journal of Algorithms	100	2.19	1777	38.92
9	9	Communications of the ACM	79	1.73	1856	40.65
10	10	ACM Transactions on Programming Languages and Systems (TOPLAS)	78	1.71	1934	42.36
		others	1934	42.36	4566	100
		Total	4566	100		

3.11 Ranking of Books

Like journals, there are few books which are frequently referred, and very close to the subject. These books frequently used frequently are more relevant to the subject and rests of the subject are dispersed among a large number of books. These most cited books are also known as the citation classic book. The table – XI shows the first 13 books titles with their number of citations. These books were placed in 10 different ranks. The most dominated title was Computers and Intractability: A Guide to the Theory

of NP-Completeness and got first position, contributing 27 citations, accounting for 1.85, second rank was occupied by The Introduction to Algorithms, contributing 23 citations, accounting for 1.57, followed by Computational Complexity, contributing 18 citations, accounting for 1.23, Foundations of Databases: The Logical Level, contributing 16 citations, accounting for 1.09 and The Design and Analysis of Computer Algorithms, contributing 13 citations, accounting for 0.89 these are in the top five ranked books.

Table - XI: Rank List of Books

S.N.	Rank	Title of the Book	No. of Citations	Cumulative citations	Percentage of Citations	Cumulative %
1	1	Computers and Intractability: A Guide to the Theory of NP-Completeness	27	27	1.85	1.85
2	2	Introduction to algorithms	23	50	1.57	3.42
3	3	Computational Complexity	18	68	1.23	4.65
4	4	Foundations of Databases: The Logical Level	16	84	1.09	5.74
5	5	The Design and Analysis of Computer Algorithms	13	97	0.89	6.63
6	5	The Probabilistic Method	13	110	0.89	7.52
7	6	Randomized algorithms	12	122	0.82	8.34
8	7	Parameterized Complexity	10	132	0.68	9.02
9	8	Introduction To Automata Theory, Languages, And Computation	9	141	0.62	9.64
10	9	Distributed Algorithms	8	149	0.55	10.19
11	10	Approximation algorithms for NP-hard problems	7	156	0.48	10.67
12	10	Finite Model Theory	7	163	0.48	11.15
13	10	Handbook of theoretical computer science (vol. A): algorithms and complexity	7	170	0.48	11.63
		Total	170		0.48	
		Others	1304	1474	88.46	100
		Grand Total	1474		100	

3.12 Rank List of Proceeding:

Research results in computer science are often published in high-quality conferences. While there are

many conferences with comparatively like scientific impact, the top-cited conferences are highly significant and need to be considered for a citation analy-

sis in computer science. Table - XII shows a rank list of Conference proceeding of having more than 10 citations. Among the top five conferences proceeding include- Proceedings of the 30th annual ACM symposium on Theory of Computing with 47 citations, accounting for 1.24%, Proceedings of the 40th Annual Symposium on Foundations of Computer

Science with 43 citations, accounting for 1.13 %, Proceedings of the 33rd annual ACM Symposium on Theory of Computing with 41 citations, accounting for 1.08 %, Proceedings of the 39th Annual Symposium on Foundations of Computer Science with 36 citations, accounting for 0.95%, Proceedings of the 31st annual ACM symposium on Theory of Computing with 33 citations, accounting for 0.87%.

Table XII: Rank List of Proceeding

S.No.	Rank	Title of the Proceeding	No. of Citations	Cumulative citations	%	Cumulative %
1	1	Proceedings of the thirtieth annual ACM symposium on Theory of computing	47	47	1.24	1.24
2	2	Proceedings of the 40th Annual Symposium on Foundations of Computer Science	43	90	1.13	2.38
3	3	Proceedings of the thirty-third annual ACM symposium on Theory of computing	41	131	1.08	3.46
4	4	Proceedings of the 39th Annual Symposium on Foundations of Computer Science	36	167	0.95	4.41
5	5	Proceedings of the thirty-first annual ACM symposium on Theory of computing	33	200	0.87	5.28
6	6	Proceedings of the twenty-ninth annual ACM symposium on Theory of computing	31	231	0.82	6.10
7	7	Proceedings of the twenty-eighth annual ACM symposium on Theory of computing	30	261	0.79	6.89
8	9	Proceedings of the thirty-second annual ACM symposium on Theory of computing	29	290	0.77	7.65
9	8	Proceedings of the thirty-fourth annual ACM symposium on Theory of computing	29	319	0.77	8.42
10	10	Proceedings of the 37th Annual Symposium on Foundations of Computer Science	26	345	0.69	9.11
		total	345	3789	9.11	100
		others	3444			
		G total	3789			

4. Conclusion

In the present study a total number of 321 articles, excluding 15 articles without citations, comprise of

10799 citations have been studied. The highest average citations per article were 37.25 in the year 2005 and the lowest average citation per article was 18.66

in the year 2003. The overall average of the citations per article for the period 1999 to 2008 was 32.14.

Like emerging scientific disciplines, in the Computer Science also the most cited sources were primary sources: journals and conference proceedings and further, both of them together have shared 77% of the total citations. The comparative analysis of use pattern of different bibliographical forms had shown no specific trend, as most of the cited forms had similar distribution in all years.

Three most recent consecutive decades, 1970-1988, 1989-1998 and 1999-2008 had contributed nearly 90% of the citations. This concludes that the most recent documents are being referred in the computer science. The overall half-life of computer science literature indicates that new libraries on computer science can consider acquiring 14 years back literature. For researchers, they may consult the journals and conference proceedings literature at least for the last 16 years and 12 years respectively from the current year while doing their research on computer science and allied subjects.

Only 3926 citations (36.88%) have been authored by single author, whereas 6719 citations (63.12%) were authored by more than one author i.e. multiple authors. It is evident that computer science being one of the emerging disciplines, most of the studies have been cited which were collaborative in nature.

O,Goldreich holds first position, contributing 105 citations, which accounts for 0.47% of the total citations. A study of top core authors whose individual papers were cited 10 and more times, along with their comparison with other positions of authorship in the papers was conducted. The core authors' solo/ individual papers had been cited only 41.74% of the total papers whereas 58.26% of the papers of

core authors cited were collaborative papers. The core authors' main papers (authored as solo paper or as first authored paper) were cited the maximum, accounting for 63.23% of the total papers, whereas only 36.77% of the papers were written by them either as a second author or higher. Highly cited papers of core authors were of collaborative nature, but mostly contributed by them as a main author; either solo or first.

The Journal of the ACM (JACM) got the first position in the rank. Among the top two most cited conference proceedings include- Proceedings of the 30th annual ACM symposium on Theory of computing with 47 citations, accounting for 1.24% and Proceedings of the 40th Annual Symposium on Foundations of Computer Science with 43 citations, accounting for 1.13 %. Like journals and proceedings, the most dominate book title was 'Computers and Intractability: A guide to the theory of NP-completeness' and got first position.

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